Addressing Hypoxia During Upper Endoscopy

René Miguel Gonzalez, MD

Anesthesiologists who provide sedation for upper endoscopic procedures, such as upper GI endoscopies, transesophageal echocardiography (TEE), and bronchoscopy are very familiar with the risk of hypoxia, sometimes profound or prolonged, that may occur during these cases.

In 2017, Goudra warned: "The growing popularity of deep sedation for upper endoscopy has created immense challenges. Deep sedation allows performing complicated procedures with relative ease. However, research suggests that airway management is anything but routine in this setting, and failure to rescue an airway at an appropriate time has led to disastrous consequences" (*Dig Dis Sci* 2017;62:45-53).

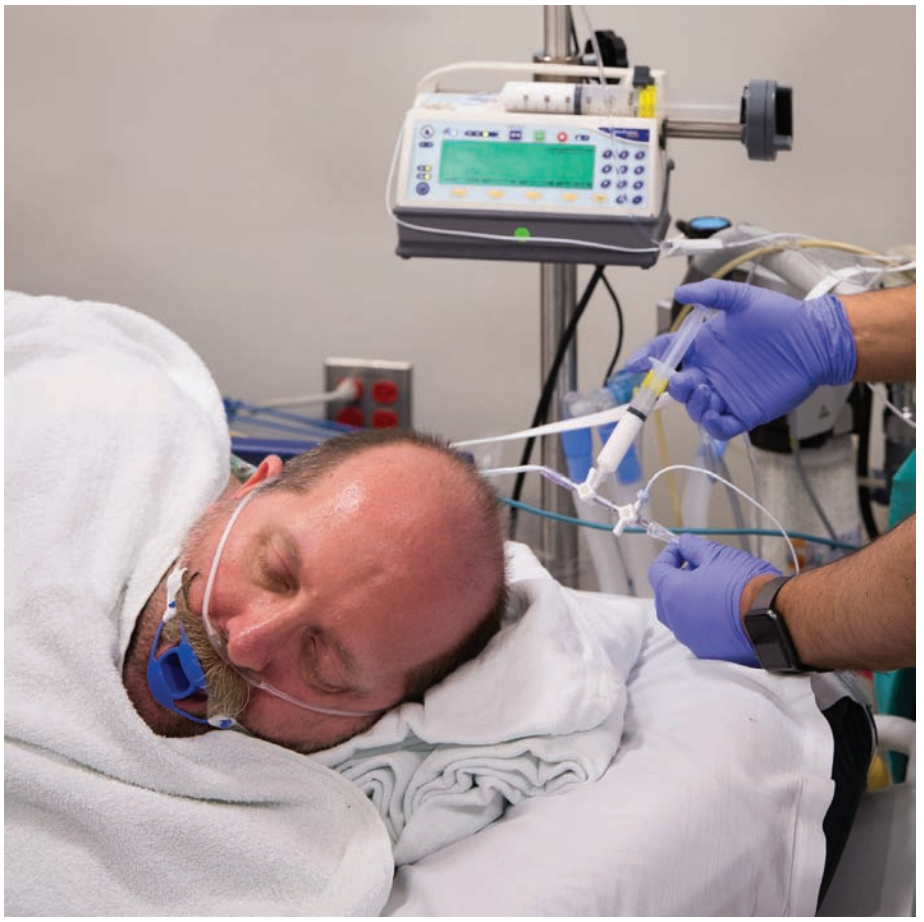
Examination of closed claims of lawsuits from non-operating room anesthetics (NORA) provides a similar warning, since a majority of claims arising from endoscopies "are related to respiratory events, specifically inadequate oxygenation" (*APSF Newsletter* 2019;34:3-4; *Curr Opin Anaesthesiol* 2010;23:523-31; *Curr Opin Anaesthesiol* 2009;22:502-8; *J Patient Safe* 2018;14:9-16).

The precise incidence of hypoxia during upper endoscopy is not known. A communication from the American Society of Gastrointestinal Endoscopy titled "Adverse Events of Upper GI Endoscopy" acknowledges the problem of obtaining accurate data: "The majority of publications rely on self-reporting, thus the rate of adverse events and mortality may be underestimated" (*Gastrointest Endosc* 2012;76:707-12). We do know, however, that the denominator is huge – the number of upper GI endoscopies performed in the U.S. in 2009 was estimated to be 7.1 million (*Gastroenterology* 2012;143:1179-87).

Sedation for upper endoscopies, even "simple" outpatient upper endoscopies, should be considered potentially high-risk from an anesthesia point of view for a number of reasons.

First, they are, by definition, "reduced airway access" cases, as the airway is shared by the endoscopist and the anesthesiologist, and because the patient is often positioned lateral or prone, facing away from the anesthesiologist. Also, room lights are often turned down or off to improve the endoscopist's view of the monitor screen.

Upper endoscopies often require deep sedation bordering on general anesthesia to suppress the potent gag, cough, and laryngospasm reflexes, especially with initial insertion or subsequent reinsertions of the endoscope. The level of stimulation – and thus depth of sedation/anesthesia – can change suddenly. Regardless of the specific sedative-hypnotic(s) used, deep sedation invariably leads to decreased respiratory drive and relaxation and collapse of the upper airway, particularly in patients with sleep apnea, or in obese, or small, or debilitated patients with decreased baseline muscle tone.

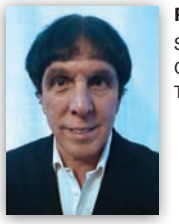


Furthermore, all upper endoscopies involve introduction of a large foreign body – the endoscope – into the upper airway. Simple geometry dramatically illustrates the magnitude of this risk. The diameter of EGD scopes is typically 8.8-11 mm. TEE scopes are typically even larger. Applying the formula for the area of a circle, $A=pi(r^2)$, it becomes evident that the cross-sectional area of a 9 mm endoscope often approximates and even exceeds the measured cross-sectional area of the upper airway, which is well documented in numerous CT studies of sedated adults, (*AJNR Am J Neuroradiol* 1996;17:1107-11; *Sci Rep* 2016;6:35849) thereby producing near-total, and even total, upper airway obstruction in a significant percentage of patients. All upper endoscopies should thus be considered iatrogenic foreign body airway obstruction cases.

Most anesthesiologists asked to provide anesthesia for a shared airway foreign body obstruction case in the operating room would probably employ the time-tested principle of maximal preoxygenation prior to induction, and continued provision of the highest-possible FIO_2 during the case.

In 1984, Drummond demonstrated, in healthy adults breathing room air, that the safe apneic time from induction of apnea until oxygen desaturation to less than 90%, is less than 60 seconds (*Br J Anaesth* 1984;56:987-93). Morbidly obese patients, and patients with increased O_2 demand (e.g., fever, hypermetabolic state), or with decreased capacity for O_2 loading (e.g., pulmonary disease, anemia), desaturate even more quickly.

It is well established, however, that the simple technique of maximal preoxygenation can significantly prolong, even double, triple, or more, the safe apneic time (*Br J Anaesth* 1984;56:987-93; *Minerva Anestesiol* 2015;81:910-20). In a 1999 editorial in *Anesthesiology*, Benumof wrote that the purpose of maximally preoxygenating before induction of general anesthesia is twofold: to maximize the time that the patient can safely tolerate apnea, and also for the provider to solve a cannot intubate/cannot ventilate scenario (*Anesthesiology* 1999;91:603-5). And since the "cannot/cannot" patient can be unpredictable, Benumof championed maximal preox for all whenever possible.



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Max preox prior to induction has become the standard for many providers (*Minerva Anestesiol* 2015;81:910-20).

However, one of the biggest challenges in sedation for upper endoscopy has been the limitation of our O_2 delivery system. The use of traditional O_2 face masks for upper endoscopy has been precluded by the fact that the mask impairs access to the mouth by the endoscopist. As a result, the O_2 delivery modalities most commonly used by default are among our least effective: traditional nasal cannula, or insufflation via oral catheter. The FIO_2 delivered by either of these is severely limited by dilution by entrained room air. Nasal cannulas, at recommended maximal flows of 5-6 L/min, provide a maximum FIO_2 of only 0.35-0.45. This FIO_2 is physiologically incapable of providing maximal preoxygenation. In addition, other common conditions, such as allergic rhinitis, nasal congestion, nasal polyps, hypertrophied turbinates, septal deviation, and mouth breathing further reduce the FIO_2 provided by nasal cannula. These conditions can also impair nasal capnography, an important monitoring modality especially in a dark environment.

As a result, devices and techniques have been recently developed to attempt to mitigate hypoxia during upper endoscopy. These have been reviewed elsewhere (*Dig Dis Sci* 2017;62:45-53; *APSF Newsletter* 2018;33:51-3; *Heart Lung Vessel* 2015;7:297-303; *Int J Med Sci* 2017;14:167-72), and include specialized oxygen masks, oxygen catheters built into the endoscopy bite block, positive pressure O_2 via modified nasal trumpets, nasal CPAP masks, and high-flow nasal oxygen (HFNO) cannulas.

After considering the options, risks, invasiveness, benefits, cost, and ease of use, our practice decided to use a device called the Procedural Oxygen Mask (POM Medical, CA). This disposable mask resembles a traditional clear plastic oxygen mask, except that it has self-sealing oral and nasal ports that allow insertion of an endoscope. It connects to standard hospital O_2 flowmeters, has a one-way expiratory valve, and can be used as a simple O_2 mask, or, by attaching the included O_2 reservoir bag, as a non-rebreather high-FIO_2 mask. When used with the O_2 non-rebreather reservoir

bag, the POM delivers FIO_2 of 0.88-0.95. It has a capnography sampling port, which detects oral and/or nasal exhaled CO_2, regardless of whether the patient is nose- or mouth-breathing. It also provides significant barrier protection to the staff should the patient cough. Its major limitation is that it cannot be used to deliver positive-pressure O_2 or ventilation.

However, because of its ability to deliver very high FIO_2, the endoscopy mask can be used to maximize preoxygenation prior to induction of sedation to prolong safe apneic time; for maintenance of high FIO_2 during the procedure; and for transport to and in PACU. For efficiency, we employ the "8 DB/60 sec" (eight deep breaths over 60 seconds) preox technique demonstrated by Baraka in 1999 to be more efficient than and as effective as the traditional five-minute tidal volume breathing preox regimen (*Anesthesiology* 1999;91:612-6).

The need for maximum preox is most obvious in patients with sleep apnea, morbid obesity, cardiac or pulmonary disease, anemia, or pre-identified difficult airway. Its benefits are most obvious in the beginning of the case when sedation is intentionally deep for scope insertion. However, there are also other possible hypoxia scenarios during upper endoscopy: coughing and laryngospasm in the young healthy patient with reactive airway reflexes; later in the case, should a large bolus of sedative be unintentionally administered after a kink in the intravenous tubing is recognized and corrected; should inadvertent disconnect or kinking of the oxygen tubing occur; at the end of the case, when the stimulus of the endoscope is suddenly removed in a still-sedated patient; or during transport to the PACU. In all of these situations, superior oxygenation could help avert a significant hypoxic episode.

As a profession, we should acknowledge that upper endoscopies are potentially high risk, foreign body airway obstruction cases. Anesthesia trainees should be taught these concepts. We should adopt criteria for quantifying the severity and duration of hypoxia. We should encourage early and aggressive intervention when the patient's saturation approaches 90% before entering the steep portion of the hemoglobin-O_2 desaturation curve, all as part of a broader effort to eradicate hypoxia.

In the spirit of the ASA's Perioperative Brain Health Initiative, anesthesiologists should strive to eliminate factors which adversely affect brain and other critical organ function. In the year 2021, there are devices and strategies available that can provide oxygenation superior to simple nasal cannula and reduce the incidence, depth, and duration of hypoxia during upper endoscopy. Our patients' brains deserve protection from hypoxia. ■

Disclosure:
René M. Gonzalez is an educational consultant for POM Medical.